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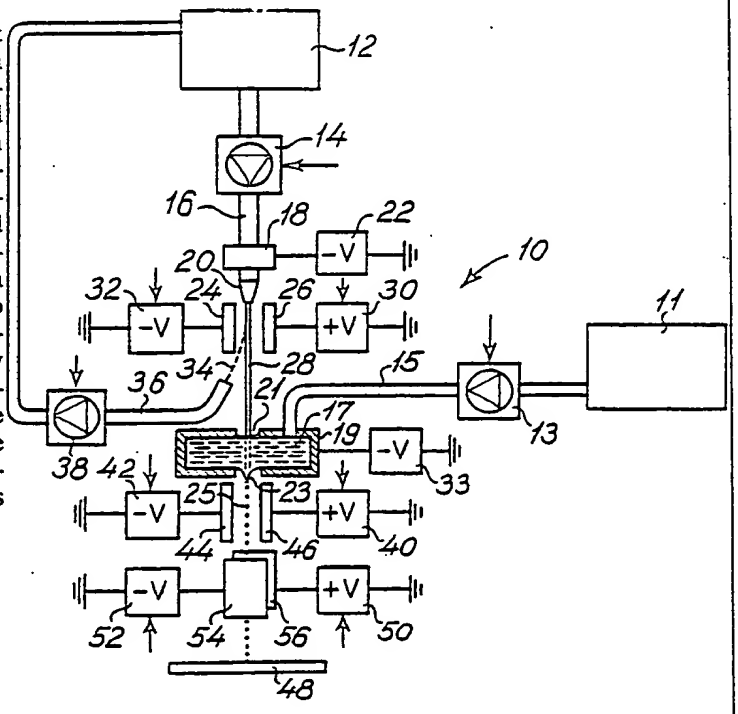
(54) Title: A METHOD OF PRODUCING AN ELECTRONIC CIRCUIT PART AND AN APPARATUS FOR PRODUCING AN ELECTRONIC CIRCUIT PART

(57) Abstract

In a method of producing an electronic circuit part (31), which contains a circuit material distributed therein, on a surface of a supporting body (48), an apparatus (10) is employed in which a stream (28) of a primary liquid is ejected under pressure from a nozzle (20) and directed through a thin layer of a secondary liquid (17) so as to form a compound liquid stream breaking up into a jet of compound liquid droplets (25). The stream of compound liquid droplets is directed towards the surface of the supporting body so as to form a deposition of the compound liquid, which is a curable liquid, on the surface. The deposition of the curable liquid is allowed to cure so as to form the electronic circuit part (31) on the surface of the supporting body (48). The primary and secondary liquids preferably constitute a primary/secondary liquid system which is a non-heat curable/two-component ink or glue system such as an epoxy or polymer based glue or ink. The stream (28) of the primary liquid and the jet of compound liquid droplets are deflectable by means of deflection plates (24, 26; 44, 46; 54, 56).



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A METHOD OF PRODUCING AN ELECTRONIC CIRCUIT PART AND AN APPARATUS FOR PRODUCING AN ELECTRONIC CIRCUIT PART

The present invention relates to novel techniques of producing electronic circuit parts.

Within the technical field of electronics, the printed circuit board technique comprising single-sided, double-sided and multilayer printed circuit boards and the layer technique comprising thin-film and thick-film layer technique have been developed and refined throughout the last decades. While the printed circuit board or PCB technique and the thin-film layer technique are based on the technique of providing a continuous surface layer, which is masked in a photo-chemical process so as to provide masked and unmasked areas, whereupon the unmasked areas are eliminated in a chemical etching process, the thick-film layer technique is based on the technique of applying a paste to a supporting body or substrate in a silk screen printing process or by means of a paste dispenser and a subsequent drying and firing of the paste. The paste typically includes a binder and an active material, which active material is constituted by fine particles homogeneously dissolved in the binder. The binder typically includes a permanent binder constituted by a glass frit or the like and a volatile binder such as an organic solvent. The thick-film technique basically has two main limitations. First, the supporting body and any components attached thereto have to be able to stand exposure to the firing temperature, which is often of the order of 800-1000°C for high temperature thick-film pastes which must be fired due to glass content, or of the order of 200°C for low temperature polymer based thick-film pastes which are cured at approximately 200°C. In accordance with the well-known thick-film layer technique it is not possible to produce circuit parts or circuit tracks in direct electrical connection with active silicon based solid state components or CMOS components or other silicon wafer based components. Second, the coarseness of the silk screens and the lack of accuracy when dispensing paste from a paste dispenser render it impossible to provide extremely fine circuit parts. Thus, by the known thick-film technique it is merely possible to provide circuit

tracks or so-called "thin lines" of a minimum dimension of approximately 200 μm with reasonably stable geometries and reproducibility. A further limitation of the known silk screen thick-film printing technique originates from the silk screen printing technique itself, as it is only possible to apply thick-film paste through a silk screen printing mesh on a substantially plane supporting body surface and even here does not result in precise thicknesses of the printed circuit parts or tracks.

Like the above described thick-film technique, the novel technique of the present invention is an additive technique, which means that in accordance with the novel technique of the present invention circuit parts are built up or made from materials, which are applied to a supporting body, in contrast to the above mentioned PCB and thin-film layer technique that leaves aggressive deposits of wasted copper resources besides being an aggressive environment. A further advantage of the novel, additive technique of the present invention as compared to the known thick-film technique is that the circuit parts are built up or made from materials which do not need to be fired at elevated temperatures, such as temperatures of 800-1000°C, for high temperature thick-film pastes which include glass frits, or of the order of 200°C for low temperature polymer based thick-film pastes. Consequently, circuit parts may be produced by the novel technique of the present invention, which circuit parts are produced in direct electrical connection with silicon wafer based components such as CMOS components or silicon based solid state components.

In accordance with the novel technique of the present invention, it is possible to apply in an additive process a circuit part to any type of substrates or supporting bodies of any geometrical configuration. In accordance with the present invention, a method of producing an electronic circuit part is provided, which circuit part contains a circuit material distributed therein, on a surface of a supporting body, which method comprises the steps of:

ejecting, under pressure, a primary liquid from a nozzle through a thin layer of a secondary liquid so as to form a compound liquid stream breaking up into a jet of compound liquid droplets, the

compound liquid being a curable liquid containing the circuit material,

discharging the jet of compound liquid droplets from a liquid discharge means,

directing the jet of compound liquid droplets towards the surface of the supporting body so as to form a deposition of the curable liquid on the surface, and

allowing the deposition of the curable liquid to cure so as to form the electronic circuit part on the surface.

By applying the curable liquid containing the circuit material in the form of a jet of compound liquid droplets, it is in accordance with the teachings of the present invention possible to apply extremely fine circuits patterns or paths on the surface of the supporting body, which circuit patterns may have a minimum dimension of less than 100-200 μm, and with spacing of 25-50 μm determined by the average diameter of the liquid droplets, which are of a diameter of approximately 20 μm. By forming the electronic circuit part from a curable liquid which is applied to the surface of the supporting body in the form of a jet of compound liquid droplets, the surface of the supporting body may further be of any geometrical configuration. Thus, in contrast to the known thick-film layer technique, the surface of the supporting body may be a non-planar, three dimensional surface, and, as will be evident from the description below, it may constitute a surface of a supporting body of any material, e.g. a material which cannot stand the high temperature firing of the known thick-film layer application technique and may further be a conductive or inconductive, flexible or non-flexible material. The material may further be a metallic material onto which insulating tracks are applied in accordance with the teachings of the present invention, and onto which insulating tracks the circuit parts are then applied. It is to be mentioned that the compound liquid droplets formation technique is known *per se* from the ink jet printing field and described e.g. in the following US patents 4.196.437, 4.346.387, and 4.620.196, which are hereby incorporated in the present specification by reference, and further in various other publications by the inventor of the above US patents.

By the utilization of a primary and a secondary liquid, several advantages are obtained. First of all, different circuit parts constituting different circuit components, tracks, etc. may advantageously be made from one and the same primary liquid, which is combined with different secondary liquids. Furthermore, as mentioned already, the employment of a primary liquid and a secondary liquid renders it possible to provide extremely small liquid droplets, i.e. of a diameter of 20 μm in that the primary liquid, which is ejected from the nozzle, may constitute a particle-free liquid, whereas the secondary liquid contains the particles constituting the circuit material, which is to be contained in the electronic circuit part to be produced. Alternatively, the primary liquid may contain particles, whereas the secondary liquid may be particle-free.

In accordance with a further embodiment of the method according to the present invention, the secondary liquid is maintained under substantially atmospheric pressure so that it is simply maintained in the atmosphere, and the secondary liquid is further maintained in a container having opposite apertures defining therebetween, through the forces of surface tension of said secondary liquid, said thin layer of said secondary liquid.

Although heat-curable liquids may advantageously be employed in connection with the present invention, it is believed, however, that a major advantage as compared to the known thick-film layer technique may be obtained by employing primary and secondary liquids together constituting a two-component curable ink, such as an epoxy or a polymer base or any other ink, preferably non-heat-curable inks having curing temperatures of the order of 25-50°C. Consequently, in accordance with the two-component curable ink aspect of the present invention the curable liquid is allowed to cure by itself by simply waiting a fairly short period of time such as 1-2 minutes.

The self-curing process (1-2 minutes of precure) allows all layers to be sprayed in a single process, as opposed to screen printers in which the scr en and subject need to be realigned several times (one time per layer). This is extremely important for flexible materials which are difficult to align with high precision. In accordance with

the method of the present invention all layers may be applied ("painted") in one process, which means that all layers align each other with the system limitations, not the realignment limitations.

The material distribution (of ink) and repeatability of component geometries - like resistors may result in no need for a resistor trimming process thus eliminating the need for trimming resistors, which are simply produced as 5-10% tolerance resistors. Only tolerances lower than 1% (special cases) requires trimming.

Although the jet of the compound liquid droplets and/or the primary liquid may be discharged and directed by means of e.g. mechanical means, the step of directing the jet of compound liquid droplets towards the surface of the supporting body is preferably accomplished by means of electrical fields, such as magnetic fields or electrostatic fields, taking into consideration the fact that basically all liquids are deflectable when exposed to electrical or electrostatic fields. Consequently, in accordance with a first embodiment of the method according to the present invention, the jet of compound liquid droplets are directed towards the surface of the supporting body by providing an electrical field defining an electrical potential gradient, through which electrical field the jet is directed so as to expose the compound liquid droplets of the jet to the electrical potential gradient and so as to deflect the jet by exposure to the electrical field.

In accordance with a second, preferred embodiment of the method according to the present invention, the jet of compound liquid droplets is directed towards the surface of the supporting body by providing an electrical field defining an electrical potential gradient, through which electrical field the primary liquid is directed from the nozzle so as to expose the primary liquid to the electrical potential gradient and so as to deflect the primary liquid by exposure to the electrical field.

The main advantag of the above second, preferred embodiment of the method according to the invention as compared to the above described first embodiment according to the invention is that the deflection of

the jet of compound liquid droplets by the deflection of the primary liquid is independent of the density of the second liquid, whereas in accordance with the above described first embodiment of the method, the deflection of the jet of the liquid droplets is dependent on the individual masses of the first and the second liquids and consequently on the densities of the two liquids, when the electrical field or the electrical potential gradient has to deflect the compound liquid droplets. Therefore, provided one and the same primary liquid is employed in connection with a variety of secondary liquids, the above second embodiment of the method according to the invention provides a method of directing the jet by electrical field deflection, which direction and electrical field deflection only depend on the characteristics of the primary liquid, viz. the ejection speed and the density of the primary liquid, and is consequently independent of the characteristics of the secondary liquid, especially the density of the secondary liquid or the material or materials contained or distributed therein.

Although the application of the liquid droplets on the surface of the supporting body may be interrupted by e.g. rapidly moving the surface away from the jet of compound liquid droplets or by arranging a mechanical screen between the liquid discharge means, from which the jet of compound liquid droplets is ejected, and the surface of the supporting body, the method preferably further comprises the step of interrupting the ejection of the curable liquid from the liquid discharge means by interrupting the ejection of the primary liquid through the thin layer of the secondary liquid. The interruption of the ejection of the primary liquid through the thin layer of the secondary liquid may obviously be provided in any appropriate manner, e.g. by means of any of the above mentioned mechanical means. However, the interruption of the ejection of the primary liquid through the thin layer of the secondary liquid is preferably accomplished by electrostatically deflecting the primary liquid ejected from the nozzle so as to direct the ejected primary liquid away from the thin layer of the secondary liquid. In accordance with this embodiment of the method according the present invention, the primary liquid may be returned in a closed circulation, because the primary liquid, which is deflected away from the thin layer of the

secondary liquid, is not mixed with the secondary liquid and consequently does not form a curable mix. The discharging of the jet of compound liquid droplets can be modulated to control the mass deposition or mass application.

In accordance with the present invention, the method preferably further comprises the step of moving the discharge means and the supporting body relative to one another so as to form a deposition of a layer configuration on the surface of the supporting body. This movement may be accomplished by moving the discharge means relative to the supporting body, by moving the supporting body relative to the discharge means or by moving both the discharge means relative to the supporting body and the supporting body relative to the discharge means, or a combination of mechanical, electromagnetic or electrostatic deflection.

Like in the conventional thick-film layer technique, the circuit material included in the electronic circuit part may be selected so as to provide a specific electronic circuit object. Thus, the circuit material may be an electrically insulating material, a semiconductor material or an electrically conductive material so as to provide an electronic circuit part constituting an insulator part, a semiconductor part or an electrically conductive part of electrically conductive tracks, respectively. It may also be curable liquids with high or low specific resistance (Rho) to form resistors.

As mentioned above, the electronic circuit part may advantageously constitute a circuit track of an electronic circuit or alternatively constitute an electronic component such as a passive electronic component, e.g. a resistor, an inductor or a capacitor, or an active component or part thereof. Further or alternatively and as indicated above, the supporting body may be of any appropriate configuration and further constitute e.g. a circuit board, such as a printed circuit board, a base board of a printed circuit board, such as a single-sided, a double-sided or multilayer printed circuit board, a thick-film or a thin-film substrate, or a component of electrically insulating or electrically conductive material, such as a housing

.Thcomponent for an electronic apparatus or a terminal of an electronic component, such as an IC-chip or an IC-housing.

A particularly advantageous feature of the present invention is the possibility of applying electronic circuit paths or electronic circuit tracks on e.g. a housing component of an electronic apparatus, such as an insulating plastics panel or the like, and further of applying the method according to the invention in the field of wire-bonding electronic components, such as IC-chips, to IC-housing terminals or the like. Wiring of a hybrid circuit is often specified as outer lead and inner lead bonding (wiring). Inner lead bonding creates contact from the chip to support legs, and outer lead bonding (wiring) creates contact from first lead pattern to second lead pattern and/or the thick-film or copper (PCB) conductor lines. Inner lead bonding, outer lead bonding and all interconnection wiring may be accomplished in a single process step in accordance with the present invention. It is believed that the method according to the present invention may be implemented in accordance with well-known aspects of the thick-film layer technique, however, preferably eliminating the firing step of the conventional thick-film process, and further be employed or modified in accordance with the thick-film layer technique. Thus, certain polymer thick-film pastes have been developed recently, and it is believed that these low-temperature or polymer-based thick-film pastes may be modified so as to constitute the curable liquid to be used in accordance with the method of the present invention. Consequently, in accordance with a further embodiment of the method according to the present invention, the curable liquid may be a heat-curable liquid. A two component type polymer based thick-film paste with long curing time has recently been developed for screen printer.

The present invention also relates to an apparatus for producing an electronic circuit part, which contains a circuit material distributed therein, which apparatus is implemented in accordance with the above described teachings of the present invention and consequently comprises:

a means for supporting the supporting body in the apparatus,

a means for ejecting, under pressure, a primary liquid from a nozzle,

a means for providing a thin layer of a secondary liquid, through which thin layer of the secondary liquid the primary liquid is ejected so as to form a compound liquid stream breaking up into a jet of compound liquid droplets, the compound liquid being a curable liquid containing the circuit material,

a liquid discharge means for discharging the jet of compound liquid droplets, and

a means for directing the jet of liquid droplets towards the surface of the supporting body so as to form a deposition of the curable liquid on the surface.

The apparatus according to the present invention may advantageously be implemented in accordance with any of the above embodiments of the method according to the present invention. Thus, the apparatus according to the present invention is preferably implemented in accordance with the above described preferred second embodiment, in which the step of directing the jet of the compound liquid droplets towards the surface of the supporting body is accomplished by electrostatically deflecting the primary liquid by means of an electrical field.

The method and apparatus according to the present invention are believed to be particularly relevant and applicable in the following micro-electronic applications:

- chip carrier interconnection
- chip bonding (inner lead bonding)
- inner lead bond for standard pin connection lay out (outer lead bonding)
- bumping of wafers
- thick-film conductor network (high and low temperature, glass- or polymer-based, single- or two-component based) on planar or non-planar carriers, substrates or supports,
- thick-film printing of dielectric components or resistors on planar or non-planar carriers,
- strapping and chipbonding of hybrid circuits,
- diebonding in general,

- dosing of electrical connection materials such a solder, conductive single- and two-component polymer and/or epoxy glue types (materials for connection through reflow or hardening),
- thin-film connection technology

and in other electrical applications such as:

- connection technology for sensors, transducers, etc.,
- thick-film fuses,
- solid or flexible bus structures,
- production of variable resistors or potentiometers, and still further the capability of the application of the method in connection with different materials:
- printing of tracks on conductors, insulators, resistors and coverings on fibre glass, aluminum oxide, stainless steel, laminates, plastics materials and metallic foils and other supporting materials with appropriate capability of adherence.

Special aspects and features of the present invention

The total processing time to produce a multilayer circuit is believed to decrease *dramatically* by employing the technique of the present invention, despite the fact that processing time per layer remains at the same level as with existing equipment.

The apparatus of the invention may be controlled directly from the data output of a CAD system (converted "gerber file"), thus eliminating film plotting for screens. 10 or more screens for individual via's, conductor dielectrics glazing are avoided for multilayer substrates.

In a conventional dust sensitive screenprinter cleaning and adjustment work is required. In the apparatus according to the present invention this is avoided due to a closed spraying chamber.

As for prototypes, production preparation may be shortened significantly due to the fact that the artwork produced on the CAD system may almost instantly be executed on a substrate, a circuit board, a supporting body, etc, examined and corrected for another

test without any plotting of film, development of a number of photo etched screens, and alignment work.

The apparatus of the invention may be built as a closed-chamber-unit, featuring two workstations, one for spraying and one for drying, or a single workstation system based on the use of two-component inks, or may be composed by 2 or 3 identical stations which are offset relative to each other to increase the production capacity.

In the case of heat-curable, preferably low temperature compound liquid (polymer base), a drying station may be constituted by one or more curing stations, if required. Two substrates may be moved between an application station and a curing station until completion, *vide* Fig. 8.

It is believed that the drying/curing process time decreases as compared to conventional thick-film technique. It is also believed that any drying/curing process may change eventually to a co-firing of layers under full control of results or be totally eliminated.. Spraying of resistor paste is also one of the fundamental features, allowing the "one gun (nozzle) one paste" concept.

The apparatus of the invention may have a full speed/flow servo control allowing the spray process to be used on various geometries of the subject and not, as in the screen printer, on flat even laser scraped surfaces. It is possible by 45° robotting of the nozzle to spray on even vertical walls. This meets the increasing demand for printing/spraying conductors directly on e.g. back planes (even on the back of the instrument panel (dash boards) in a car) following the material profilation. It may end up in differently shaped constructions of the apparatus according to the invention, for different applications, but it does not conflict with basic system performance.

The day to day work with an apparatus of the present invention is believed to greatly reduce time consuming set up, adjustment of screens, initial test runs, screen cleaning problems due to dry out of organic content, and general screen cleaning from day to day. In

total it is foreseen that material consumption is reduced radically . In a primary/secondary liquid two-component ink system no waste products are produced that may be hazardous to the environment.

The organic content of both high and low temperature compound liquids (especially on low-temperature polymer basis) is a problem to the environment in the open construction which a screen printer by nature represents. The encapsulated spraying apparatus according to the invention will have no uncontrollable influence on the environment.

It is believed that the method of the present invention is costwise profitable to both PCB-technology and thick-film methods. The low cost may be measured in less material used, less production steps, less waste of material, and less environment precautions. It is further believed that the installation costs are considerably lower, thus allowing medium size companies to produce themselves, instead of being forces to do subcontracting.

The full control of speed versus flow of liquid in the apparatus according to the invention results in a controlled thickness of material in the geometric area for e.g. resistors. It is believed that this control together with a better controlled material distribution may result in resistors with a better tolerance after curing/firing and may lead to the end of expensive laser trimmers (air abrasive trimmers) except for high demands on tolerance (< 5%).

One of the problems in printing thin line conductors by means of screen printers is edge definition. Another one is the conductivity. The thick-film pastes used today give no perfect material distribution of metal pigments, and the distance between these results in decreased conductivity on thin conductors due to loss of area in thin line technology - maybe the pigments are encapsulated by oil, or the other content represents "spacers" between the pigments. Since the content of circuit material in the compound liquid may be increased as compared to conventional thick-film pastes, it is believed that conductivity may be improved allowing the thin line technology without conductivity trade off to a certain extent. This will match the conductivity close to the conductivity already

obtained in PCB-technology, thus eliminating the only advantage of PCB technology as compared to conventional thick-film production techniques, except for the price.

An alternative to screen printers already on the market are injection spray systems, principally comparable with hypodermic needles. These systems cannot spray with geometric response as can the apparatus according to the present invention, since the pigments have to pass the hypodermic needle. Besides, the cut off of injection is slow resulting in unwanted geometry of start and end of a printed conductor. The apparatus according to the present invention may be controlled to cut off the droplets in 1 μ second, and further with full control over flow and speed. Since approximately 10^6 droplets are produced per second, every single droplet may be controlled to be allowed to pass or to be eliminated. By this individual droplet control the spraying and application density may be controlled, particularly in relation to geometrical shape - variation in height or z-coordinate - or in relation to the speed of movement of the apparatus relative to the receiving surface.

The novel technique of the present invention renders it possible to provide circuits on non-planar surfaces including active and passive components glued to the surface and connected through circuit tracks to the circuit parts provided in accordance with the teaching of the present invention. However, circuits provided on non-planar surfaces cannot be inspected by known circuit testers which require that the finished circuit is arranged in a circuit testing machine. Since, in accordance with a preferred aspect of the present invention the apparatus is moved in relation to the surface on which the circuit parts are to be provided, the novel technique according to the present invention calls for a combination of the circuit application technique described above and a visual inspection which is carried out simultaneously with the application of the circuit parts or circuit tracks, and which visual inspection is carried out in accordance with circuit pattern recognition techniques combined with the design of the circuit pattern, circuit part or circuit track in question based on the CAD system layout. Consequently, the novel technique according to the present invention renders it possible in

one and the same production step to provide a finished circuit comprising a multiplicity of components, some of which are provided in "discrete" form, and some of which are provided in accordance with the method of the present invention, and which circuit is at the same time tested by a visual pattern recognition testing. The visual testing may be performed by means of e.g. a camera, a fibre optic scanner etc.

The invention will now be further described with reference to the drawings, on which

Fig. 1 is a schematic and partly sectional view of a first embodiment of an apparatus of the present invention, which apparatus illustrates the method of the present invention,

Fig. 2 is a vertical sectional view illustrating in greater detail the application technique involved in applying compound liquid droplets by means of the apparatus shown in Fig. 1 in accordance with the teachings of the present invention,

Fig. 3 is a perspective and schematical view illustrating a first method of electrostatically controlling the deposition of compound liquid droplets in accordance with the teachings of the present invention,

Figs. 4 and 5 are perspective views illustrating further implementations of the apparatus according to the present invention further illustrating the highly advantageous feature of the method according to the present invention, in accordance with which feature a circuit pattern may be applied to a surface of a supporting body of any geometrical shape,

Fig. 6 is a schematical view illustrating individual steps of the production of a circuit board in accordance with the method of the present invention,

Fig. 7 is a perspective view illustrating a highly advantageous feature of the method and the apparatus according to the present invention within the technical field of bonding integrated circuit chips to terminals of integrated circuit housings,

Figs. 8, 9 and 10 are schematical views illustrating respective production processes involving heat-curable liquids, in a recirculation production process, in a step-by-step production

process, and in a multi-chamber production process involving a two-component instantaneously curing liquid, respectively,

Fig. 11 is a schematical view illustrating a particular feature of the novel technique according to the present invention, according to which feature the apparatus according to the present invention is simply controlled in accordance with a CAD control scheme provided in a CAD system,

Fig. 12 is a schematical and perspective view of a presently preferred embodiment of an apparatus according to the present invention comprising a multiplicity of secondary liquid reservoirs, and

Fig. 13 is a perspective view illustrating individual steps of establishing electrically conductive connection to components, such as silicon based chips mounted, e.g. glued, to the top side surface of the supporting body or substrate by utilizing the method according to the present invention.

In Fig. 1, an apparatus 10 is shown for producing an electronic part on a surface of a supporting body, a substrate or a circuit board in accordance with the method according to the present invention. Basically, the apparatus 10 is an apparatus for applying a circuit part in the form of a jet of compound liquid droplets to the surface on which the electronic circuit part is to be produced. The jet of compound liquid droplets is produced from two liquids, a primary liquid and a secondary liquid. The primary liquid is contained in a reservoir 12, from which the primary liquid is supplied, in a continuous stream in the operation of the apparatus 10, to a pressure pump 14, which delivers a continuous, high pressure supply of the primary liquid through a conduit 16 to a discharge nozzle 20. The conduit 16 is connected through a connector terminal 18 to a voltage source 22, which maintains the terminal 18 and consequently the nozzle 20 at a fixed potential relative to the ground of the apparatus 10, if charged liquid droplets are required. Obviously, the reservoir 12, the pump 14, the conduit 16, the terminal 18 and the nozzle 20 or at least the terminal 18 and the nozzle 20 are insulated relative to the ground of the apparatus 10 so as to enable the voltage source 22 to maintain the terminal 18 at the fixed potential relative to the ground of the apparatus 10. The potential may be e.g.

the ground potential, a positive potential or as disclosed in Fig. 1 a negative potential. Furthermore, the voltage source 22 may be a variable voltage source. By maintaining the terminal 18 and the nozzle 20 at the fixed potential controlled and determined by the voltage source 22, the liquid which is discharged in a continuous, high pressure stream 28 from the nozzle 20 is also at the potential determined by the source 22 relative to the ground of the apparatus 10. Since basically all liquids are deflectable by exposure to electrostatic fields, the stream 28 may be deflected from its path along a straight line by means of an electrostatic deflection means.

In Fig. 1, the stream 28 may be deflected from its straight line by applying potentials, which are different from the ground potential and different from the potential determined by the voltage source 22, to deflection plates 24 and 26, which are connected to controllable or variable voltage sources 32 and 30, respectively. By exposing the stream 28 to a high-strength electrostatic field, the stream 28 may be bent or deflected away from the path along the straight line to a deflection path 34, by which deflection the liquid stream 28 discharged from the nozzle 20 is received in a tube 36, which conducts the liquid back to the primary liquid reservoir 12. In the tube 36, a pump 38 is arranged.

Provided the voltage sources 30 and 32 are not activated so as to deflect the liquid stream 28 to the deflection path 34, the liquid stream 28 discharged or ejected from the nozzle 20 is introduced in a container 19 through an aperture 21 thereof. The container 19 is filled with a secondary liquid 17, which is provided from a secondary liquid reservoir 11 through a conduit 15, in which a controllable pump 13 is arranged. The pump 13 is controlled by means of *per se* conventional means so as to maintain a constant liquid level in the container 19. The container 19 and the secondary liquid 17 are maintained at a fixed potential relative to the ground of the apparatus 10 by a voltage source 33. Apart from the aperture 21, through which the primary liquid stream 28 is introduced into the container 19, the container 19 is provided with a further aperture arranged opposite the aperture 21, from which further aperture a compound liquid stream 23 is discharged.

It is to be understood that the aperture 21 and the further aperture of the container 19 are adapted relative to the forces of surface tension of the secondary liquid 17 so that a thin layer of the secondary liquid 17 is maintained between the two oppositely arranged apertures. As already mentioned, a compound liquid stream comprising the primary liquid and the secondary liquid is discharged as indicated by the reference numeral 23 from the aperture arranged opposite the aperture 21. It is to be understood that the stream 28 is discharged from the nozzle 20 at a high velocity and decelerated by the secondary liquid 17. However, the discharge velocity of the primary liquid from the nozzle 20 is so high that the primary liquid is not stopped by the thin layer of the secondary liquid 17 but carries along part of the secondary liquid 17 in a compound liquid stream. As first realized by the inventor of the US patents 4.196.437, 4.346.387 and 4.620.196, which are hereby incorporated in the present specification by reference, the compound liquid stream 23 breaks up into separate compound liquid droplets 25. By the above described technique of producing a compound liquid stream breaking up into compound liquid droplets by forcing a primary liquid through a thin layer of a secondary liquid, an extremely exact and reproducible droplet dosing is provided.

Like the liquid stream 28, the stream of droplets produced from the compound liquid 23 discharged from the container 19 may be deflected by means of electrostatic deflection means. In Fig. 1, two pairs of electrostatic plates 44, 46 and 54, 56 constitute a pair of X and Y deflection plates. The first set of deflection plates, the X deflection plates 44 and 46, are connected to controllable voltage sources 42 and 40, respectively, whereas the second set of deflection plates, the Y deflection plates, 54 and 56, are connected to controllable voltage sources 52 and 50, respectively. As will be evident from the disclosure below, the X and Y deflection plates may be shifted from the position shown in Fig. 1 to a position above the container 19 and one of the sets of deflection plates may be omitted. In Fig. 1, the deflection of the stream of droplets 25 depends on the velocity of the stream of droplets 25 and further on the mass of the individual droplet 25. The mass of the individual droplet 25 and the

velocity thereof further depend among other factors on the densities of the primary and secondary liquids. In case the sets of deflection plates 44, 46 and 54, 56 are shifted from the position shown in Fig. 1 to a position above the container 19, the deflection of the stream of droplets 25 is provided by deflecting the stream 28, which deflection is independent of the characteristics of the secondary liquid. Therefore, in case one and the same primary liquid is used for producing circuit parts containing different circuit materials, which circuit materials are contained in the secondary liquid and which secondary liquid determines the characteristics of the circuit of the circuit component in question, the deflection of the stream of droplets 25 may be controlled independently of the secondary liquid in question, which secondary liquid is contained in the container 19 and further included in the individual droplets 25. The stream of droplets 25 is directed and, as will be understood, deflected by means of the deflection plates 44, 46 and 54, 56 to an upper side surface of the supporting body 48, which may constitute a circuit board, a substrate, a part of a housing, a panel, etc., as will be evident from the disclosure below.

In Figs. 2 and 3, the above described apparatus 10 is shown illustrating the method according to the present invention of producing a circuit part 31 on the surface of the supporting body 48. In Fig. 2, most of the components of the apparatus 10 except the pumps 13, 14 and 38 and the reservoirs 11 and 12 are included in an outer housing, which comprises a cylindrical housing part 60 and a lower conical housing part 58 provided with an aperture 59, through which the stream of droplets 25 is discharged. Apart from the above described components, the apparatus 10 further preferably comprises means for moving the apparatus 10 and the supporting body 48 in relation to each other as will be evident from the description below. By the relative movement of the apparatus 10 and the supporting body 48, a continuous layer 31 is provided on the upper side surface of the supporting body 48. As is evident from Fig. 3, the layer 31 may, apart from the dimension determined by the relative movement of the apparatus 10 and the supporting body 48, be provided in a dimension perpendicular to the direction of the above movement by deflecting the stream of droplets 25 by means of one of the sets of deflection

plates. In Fig. 3 the deflection plates 44 and 46 are shown schematically serving the purpose of controlling the deflection of the stream of droplets 25 perpendicularly to the longitudinal dimension of the circuit part 31 for providing a dimension of the circuit part 31 perpendicularly to its longitudinal direction, which in Fig. 3 corresponds to the direction of movement of the supporting body 48 in relation to the apparatus 10. In Fig. 3, two dotted lines 27 and 29 illustrate the boundary lines within which the stream of droplets 25 is controlled by the deflection by means of the plates 44 and 46 for providing the continuous circuit part or circuit track 31. In Fig. 3, a droplet 33 is shown, which is just about to contact the upper side surface of the supporting body 48. As is further evident from Fig. 3, the droplets, e.g. the droplet 33, are contacting adjacent droplets previously deposited on the upper side surface of the supporting body 48 and together provide a continuous layer, which runs out into a homogeneous layer due to gravitation, inherent surface tension forces, and further forces of attraction between the individual droplets and the molecules thereof. Furthermore, in a single production step a "multi-layer" conductor may be provided by simply applying several layers of droplets on top of one another. This is particularly important in connection with extremely thin lines, e.g. lines of a width less than 100 μm.

It should be understood that the liquids constituting the primary and the secondary liquid may constitute a heat-curable liquid system. The primary liquid is preferably particle free, whereas the secondary liquid preferably contains a material, which may be constituted by fine particles, and which further defines the properties of the circuit part which is produced, such as the properties of the circuit part 31 shown in Figs. 2 and 3. The circuit part 31 may constitute an insulator, a semiconductor, a conductor by the provision of electrically insulating material, semiconductor material, a material with low conductance (resistor material), or electrically conductive material, respectively, in the secondary liquid. Thus, the primary liquid simply constitutes a carrier liquid, which carries the secondary liquid from the container 19 to the surface part of the supporting body 48, on which the circuit part or circuit track is to be produced. Thus, the primary liquid may be a volatile liquid, which

evaporates from the compound liquid after the deposition of the droplets, such as the droplet 33 shown in Fig. 3, on the surface of the supporting body 48. Apart from the material defining the electrical properties of the final circuit part the secondary liquid may include a permanent binder such as a glass frit or a polymer material, which like conventional thick-film pastes provides a sintering or permanent binding of the circuit part together and further to the supporting body in a heating or firing process. It is believed, however, that the primary and secondary liquids may constitute a two-component ink system such as an epoxy ink system or polymer ink system or the like, in that the primary and the secondary liquid may constitute a binder and a hardener, respectively, or vice versa, so that the circuit part 31 may simply be produced by mixing the binder and the hardener of the two-component ink system in the compound liquid droplets 25 which after a short period of time, such as 1-2 minutes, solidify and together with adjacent liquid droplets constitute a continuous layer such as the layer 31 shown in Fig. 3.

A further attractive aspect of the method and the apparatus of the present invention is shown in Figs. 4 and 5. In accordance with conventional layer techniques, particularly conventional thick-film layer technique, the thick-film pastes may only be applied to substrates which firstly can stand exposure to the thick-film paste firing temperature and secondly define a basically plane surface, onto which the thick-film paste is applied in a screen printing process or by means of a thick-film paste dispenser. Contrary to this known technique, the apparatus 10 may be arranged on a system of supporting brackets and arms, *vide* Figs. 4 and 5, so as to render it possible to arrange the apparatus 10 in any position in relation to the supporting body, onto which a circuit part is to be provided, and further to produce a movement of the apparatus 10 in relation to the supporting body.

In Fig. 4, a supporting body 71 is shown which comprises wall components 73, 74, 75, 76 and 77, on which circuit tracks are to be provided by means of the apparatus 10. In Fig. 4, one of the circuit tracks provided on the outer side surface of the supporting body 71 is designated 72. It should be realized that the circuit tracks shown

in Fig. 4 could not possibly be provided on the non-planar supporting body 71 in a silk screen printing process. In Fig. 4, the apparatus 10 is shown with its fluid conduits 15, 16 and 36 extending from an upper wall part, whereas the electrical connections to the deflection plates are constituted by a single multicore cable 61. In Fig. 4, the conical housing part 58 is also shown. As mentioned above, the apparatus 10 shown in Fig. 4 is moved in relation to the supporting body 71. Thus, the apparatus 10 is mounted on a piston 62, which may be turned, stretched out and retracted as illustrated by double arrows in relation to a bushing 63, which is mounted on a body 64. The body 64 is received in a slot 66 of a housing 68 and may be moved in the slot 66 by means of mechanical guide means, not shown in Fig. 4, as illustrated by a double arrow at the top surface of the body 64. The housing 68 is further provided with a bushing 69 through which a piston arm 70 extends, which piston arm 70 is fixed to a support, not shown in Fig. 4. By means of the piston arm 70, the housing 68 and the components attached thereto and consequently also the apparatus 10 may be moved up and down in relation to the above mentioned support as illustrated by a double arrow adjacent to the bushing 69.

As compared to the embodiment of the apparatus according to the invention shown in Fig. 4, a slightly modified embodiment of the apparatus according to the invention is shown in Fig. 5. The apparatus 10 shown in Fig. 5 is mounted on a robot arm system comprising three robot arms 80, 81 and 82 and a fixation bracket 84 which is fixed to a fixation support bracket 86. By means of the robot arm system 80-82 the apparatus 10 may be turned around and moved inside a closed housing 91, which comprises three outer walls, one of which is designated 93, and further a skirt wall 94. On the inner side surface of the walls of the housing 91, circuit tracks are provided in accordance with the method of the present invention, one of which circuit tracks is designated 92 in Fig. 5. When the apparatus is moved by means of the robot arm system 80-82 in e.g. a z-direction, a different flow of droplets versus x-y-z directional speed may be required. Thus a reduced number of droplets per time unit may be produced by the apparatus 10.

Alternatively, the apparatus may be maintained in a fixed position while the body 91 shown in Fig. 5 may be moved in the three dimensions relative to the apparatus, depending on the application.

As will be discussed below, the apparatus according to the present invention may be employed for applying a single circuit component part on a supporting body. Alternatively, one and the same apparatus according to the present invention may in accordance with a further embodiment to be described below with reference to Fig. 12 provide different circuit parts of different electrical properties. It is to be realized, however, that the compound liquid droplet application technique according to the present invention brings about certain amendments or modifications as compared to conventional circuit application techniques, in that the stepwise application of circuit parts in accordance with the teachings of the present invention obviously results in certain modifications as compared to e.g. conventional thick-film layer application technique.

In Fig. 6, the results of four production steps are shown, in which individual production steps circuit parts or circuit patterns are provided from one and the same material. In a first production step, a circuit material, such as a resistor material is applied to an upper side surface of a circuit board designated the reference numeral 100. The result of the first production step is shown in the upper part of Fig. 6 in that three resistors 101 are arranged on the upper side surface of the circuit board 100. In a second production step, a different circuit material, such as a circuit material of high electrical conductivity is applied to the upper side surface of the circuit board 100, which application results in the provision of circuit tracks arranged on the upper side surface of the circuit board 100 shown below the uppermost circuit board 100. The circuit tracks provided in the second production step are designated 102. In a third production step, insulating layers designated 103 are arranged on specific areas of the circuit tracks provided in the first and second production steps, i.e. on the resistor 101 and on the conductors 102. In a fourth and final production step, circuit tracks are applied to the circuit board 100 in electrically

conductive connection with specific parts of the previously applied electrical conductors 102 or the previously applied resistors 101, which electrical conductors provided in the fourth production step run across the previously applied resistors 101 and the previously applied electrical conductors 102 insulated in relation to the previously applied resistors 101 and the previously applied electrical conductors by the intervention of the insulating layers 103. Obviously, the conductors 104 may be of the same material as the conductors 102. It is to be realized that in the production process described above, the insulating layers 103 are only provided at those parts of the previously applied circuit tracks which parts are to be insulated in relation to the circuit tracks which are to be applied in a later step. This is in contrast to the conventional thick-film application technique, in which the insulating layer would normally have been a continuous layer covering the major part of the upper side surface of the circuit board 100. Thus, the novel technique of the present invention results in a radical material saving as compared to the conventional paste application technique.

A major advantage as compared to the known thick-film technique is achieved through the fact that in case of two-component inks drying for 1-2 minutes, the whole multilayer unit may be provided in a single operation. This allows an extremely improved registration from layer to layer since the substrate does not leave the machinery six or seven times to be reinstalled after drying/firing and realigned relative to screens for the various layers as is the case with conventional screen printers. The present invention registers the various layers to its own precision limitations, and does not include any registration or re-registration tolerances. This allows the production of thinner lines and smaller spacings than obtainable till now. Some materials (such as flexible materials) are difficult to register at all. By producing all layers at the same time, the interlayer registration is kept precise and any realignment problem is eliminated.

In Fig. 7 a highly advantageous application of the novel technique according to the present invention is shown. A base board 110 of an integrated circuit housing is shown. From the base board 110, pin

terminals 112 extend, and on the upper side surface of the base board 110 an integrated circuit wafer chip 111 is arranged and fixed e.g. in a glue connection. In accordance with the conventional wiring technique, the terminals of the integrated circuit wafer chip 111 are connected to respective terminal pins 112 by wire bonding for an inner lead frame Mylar. Conventional wire bonding technique, however, is a highly time consuming and highly delicate and critical technique, and this also applies for inner lead bonding with lead frames. It is believed that the method according to the present invention may advantageously be employed for establishing electrically conductive connection between terminals of the integrated circuit wafer chip 111 and respective terminal pins 112. Thus, in Fig. 7, circuit tracks or parts 113 are shown, which are provided in accordance with the teachings of the present invention.

As mentioned above, the primary and secondary liquids which are applied in accordance with the teachings of the present invention may constitute a heat-curable liquid. In Fig. 8, a possible production system is shown, in which one and the same circuit board or supporting body 48 is circulated, as indicated by arrows, between an application chamber 115 and a curing chamber 116. In the application chamber 115, the apparatus 10 according to the present invention is arranged, whereas two heat radiators 119 are arranged in the curing chamber 116, from which evaporated gases are vented through a vent 118.

The production process described above with reference to Fig. 8 may be modified into a stepwise production technique, which is illustrated in Fig. 9. In a first liquid application chamber 115a, which basically corresponds to the above described chamber 115, an apparatus 10 according to the present invention is arranged, into which first liquid application chamber 115 a circuit board 48a is introduced. After the completion of the process in the chamber 115a, the circuit board 48a is moved to a first heating or curing chamber 116a, which basically corresponds to the curing chamber 116 shown in Fig. 8. In the chamber 116a a circuit board 48b is exposed to a curing process and then moved to a second application chamber 115b, in which a compound liquid is applied to a circuit board 48c present

in the chamber 115b in accordance with the teachings of the present invention. From the second application chamber 115b, the circuit board 48c is moved to a second curing chamber 116b, in which a circuit board is designated 48d. Obviously, the processes described above with reference to Figs. 8 and 9 may be modified in numerous ways. Thus, the individual application chambers, such as the chamber 115 shown in Fig. 8 or the chambers 115a and 115b shown in Fig. 9, may be modified by the provision of a plurality of apparatuses 10 according to the present invention in case the production time requires more than one application apparatus per application chamber. Thus, it is to be realized that in a continuous production process, the circuit board should not be resting in a chamber for a prolonged period of time, as the production time per chamber should preferably be one and the same.

In case a non-heat-curable primary/secondary liquid two-component system is used, the heating or firing chambers shown in Figs. 8 and 9 may be omitted. In Fig. 10 a modified production system, in which a non-heat-curable primary/secondary liquid system such as a two-component system, is shown comprising the chamber 115, in which three individual apparatuses 10a, 10b and 10c are arranged for the application of respective circuit or circuit tracks on the circuit board 48. The apparatuses 10a-10c may alternatively be of a type shown in Fig. 12, to be described below, which type renders it possible to apply different circuit parts including different circuit materials by means of one and the same apparatus on the basis of one and the same primary liquid.

A particular aspect of the present invention is a simple controlling of the operation of the apparatus 10. Nowadays most electronic circuits are drafted in computer aided design (CAD). In the lower left hand side of Fig. 11, a CAD system is shown which comprises a main computer or CPU 170 which is connected to a mouse 172, which is arranged on a drawing plate 171, and which central computer 170 is further connected to a keyboard terminal 173, a display unit 174 and a data recording station 176, in which the data generated in the CPU 170 are stored on a data carrier such as a data tape, floppy disk or a data card. On the display unit 174, the circuit is displayed to the

operator of the CAD system, and the displaying is designated 175. In the upper-right hand side art of Fig. 11 the apparatus 10 according to the invention is shown together with a supporting body 48 or a substrate, a circuit board or the like, on which a circuit track 31 has been applied by means of the apparatus 10. The apparatus 10 is controlled by a computer 178, which receives the data previously stored on the above mentioned data carrier from a data reading station 177, in which the data are red from the data carrier and transferred to the computer 178, which is connected to an interface apparatus 180, which is further connected to the apparatus 10. The interface apparatus 180 is an apparatus which includes the electronic circuitry, and which controls the operation of the apparatus 10 and further the liquid reservoirs 11 and 12, the pumps 13, 15 and 38, the voltage sources connected to the deflection plates etc., and further the mechanical transport means, which position the apparatus in relation to the circuit board 48, e.g. as discussed above with reference to Figs. 4 and 5. Obviously, the interface apparatus 180 may control a plurality of individual apparatuses 10 according to the present invention each adapted to provide a circuit part or track of a specific electrical property. The CAD information may be accompanied by z-direction information, so that the CAD information is three-dimensional when producing network on non-planar objects or bodies.

In Fig. 12 a presently preferred embodiment of a nozzle system of the apparatus according to the present invention is shown, which nozzle system renders it possible to discharge compound liquid droplets of more than one composition. In this embodiment the deflection of the stream of droplets 25 is further accomplished by deflecting the primary liquid stream 28 prior to the ejection of the primary liquid stream through the thin layer of the secondary liquid. The deflection of the liquid stream 28 is provided by means of deflection plates 124 and 126, which are connected to controllable voltage sources 132 and 130, respectively, which apply specific voltages relative to the ground of the apparatus to the deflection plates 124 and 126.

The deflection plates 24 and 26 and the voltage sources 32 and 30 connected thereto, shown in Fig. 1, are omitted in Fig. 12. The

embodiment shown in Fig. 12 is instead provided with a trough-shaped metallic receptacle 122 which is connected to a controllable voltage source 133, which receptacle 122 and which voltage source 133 serve the purpose of deflecting the liquid stream 28 from its straight path to the receptacle 122, from which the liquid is returned to the primary liquid reservoir, not shown in Fig. 12, but corresponding to the reservoir 12 shown in Fig. 1, through a conduit 136, in which a pump 138 is arranged. This arrangement also serves to modulate the primary stream 28 which controls the number of droplets produced and, consequently, thus the mass of compound liquid produced per time unit. Like in the embodiment shown in Fig. 1, the nozzle 20 and the tube 16 is maintained at a specific potential in relation to the ground of the apparatus by the voltage source 22. As is evident from Fig. 12, the deflection plates 126 and 124 provide a deflection of the straight line liquid stream 28, which is designated 128 after its deflection.

As mentioned above, it is believed that one and the same primary liquid may constitute a carrier liquid for different secondary liquids. If so, the deflection of the jet of droplets 25 is preferably accomplished by simply deflecting the stream of the primary liquid as shown in Fig. 12.

In Fig. 12 three containers 141, 142 and 143 are shown, which are mounted movably on guiding rods 144, and which containers include respective secondary liquids used for providing different circuit parts in accordance with the teachings of the present invention. Each of the secondary liquid containers 141-143 is provided with an aperture 145, 146 and 147, respectively, and like the aperture 21 shown in Fig. 1, each aperture is intended for the introduction of the primary liquid stream 128 into the thin layer of the secondary liquid. Each of the secondary liquid containers 141-143 is obviously provided with an aperture adjacent to and opposite to the aperture 145-147.

Between the aperture for introducing the primary liquid and the adjacent, oppositely positioned aperture, not shown in Fig. 12, a thin layer of the secondary liquid is provided by the forces of

surface tension of the secondary liquid. A constant liquid level of the secondary liquid containers is maintained as discussed above. Thus, the secondary liquid containers 141, 142 and 143 are connected to pumps 151, 152 and 153, respectively, through flexible tubings 148, 149 and 150, respectively. As is evident from Fig. 12, the secondary liquid containers 141, 142 and 143 together constitute an assembly, which is moved up and down by means of a piston 155, which is connected to a rack 156 cooperating with a pinion 157 which is mounted on the drive shaft of an electrical motor 158. By operating the electrical motor 158 and shifting the rack 156 up and down, one of the secondary liquid containers 141-143 may be positioned with its introduction aperture 145-147 in the primary liquid stream path. Instead of the piston, rack and pinion shown in Fig. 12, any other positioning means, such as hydraulic, pneumatic or linear electro-motor control means may be provided.

In Fig. 13 a very attractive aspect of the present invention is shown, viz. the aspect of directly establishing connection to electronic components which cannot stand exposure to elevated temperatures, e.g. the temperatures normally used in the firing of thick-film pastes. Thus, it is believed that by the provision of a two-component glue constituted by the relevant primary and secondary liquids, it will be possible to provide circuit tracks in direct electrically conductive connection with e.g. solid state components, such as CMOS chips and high precision passive chip components which should not be exposed to elevated temperature, etc. In Fig. 13, a circuit board 200 is shown, on which four components 198 are arranged, e.g. glued to the circuit board. By means of the apparatus described above with reference to Fig. 4, resistor circuit tracks 201, electrical conductor tracks 202, electrical insulating layers 203, and electrical conductor tracks 204 are provided on the upper side surface of the circuit board 200, as discussed and described with reference to Fig. 6, and as illustrated in the central part of Fig. 13. One of the circuit tracks is designated 205 and crosses the previously produced circuit track, however ending adjacent to a component 198. In a final production step shown in the lower, left-hand side of Fig. 13, circuit tracks 206 are provided, which establishes electrically conductive connection between the component

198 and the circuit track 205. The final production step may e.g. be carried out by means of a separate apparatus, such as an apparatus 10' shown in phantom lines in the left-hand side of Fig. 13.

It is relevant now to compare this two step method with conventional screen printing. The rejection of the three step (printing, drying, firing) up to 300 times a very complex application plus the trimming and chip positioning process and bonding is turned into a two step process, eliminating registration, bonding, and trimming problems. The method also eliminates the need for wave or reflow tin soldering (PCB/SMD techniques) - which means that the major sources to low yields and missing contact - the tin soldering is completely eliminated.

Furthermore, the two step process shown in Fig. 13 may be completed with visual inspection systems (pattern recognition), a first system controlling that the chips are glued correctly oriented, and a second system controlling that the tracks 206 are provided and are correctly and properly connected to the terminals of the chips for checking the quality of the tracks etc at the very time they are produced by the apparatus controlled by basic information from the CAD system. A distance measuring system may also be provided for adjusting the nozzle in z-direction according to the z-direction tolerances of the subject. Such a distance measuring system is required only if the tolerances exceed 2-3 mm. The distance measuring system may be controlled by the CAD information.

It is to be realized that although the invention has been described with reference to a plurality of specific embodiments of the method and the apparatus according to the present invention, numerous modifications and amendments are obvious to the skilled art worker within the scope of the present invention as defined in the appending claims.

CLAIMS

1. A method of producing an electronic circuit part, which contains a circuit material distributed therein, on a surface of a supporting body, comprising the steps of:

ejecting, under pressure, a primary liquid from a nozzle through a thin layer of a secondary liquid so as to form a compound liquid stream breaking up into a jet of compound liquid droplets, said compound liquid being a curable liquid containing said circuit material,

discharging said jet of compound liquid droplets from a liquid discharge means,

directing said jet of compound liquid droplets towards said surface of said supporting body so as to form a deposition of said curable liquid on said surface, and

allowing said deposition of said curable liquid to cure so as to form said electronic circuit part on said surface.

2. A method according to claim 1, wherein said circuit material is constituted by particles contained in said secondary liquid, and wherein said primary liquid is particle-free.

3. A method according to claim 1 or 2, wherein said secondary liquid is maintained under substantially atmospheric pressure conditions.

4. A method according to claim 3, wherein said secondary liquid is maintained in a container having opposite apertures defining therebetween, through the forces of surface tension of said secondary liquid, said thin layer of said secondary liquid.

5. A method according to any of the preceding claims, wherein said primary and secondary liquids together constitute a two-component curable ink, such as an epoxy or polymer base ink.

6. A method according to any of the preceding claims, wherein said step of directing said jet of compound liquid droplets towards said surface of said supporting body comprises: providing an electrical

field defining an electrical potential gradient, through which electrical field said jet is directed so as to expose said compound liquid droplets of said jet to said electrical potential gradient and so as to deflect said jet by exposure to said electrical field.

7. A method according to any of the preceding claims, wherein said step of directing said jet of compound liquid droplets towards said surface of said supporting body comprises: providing an electrical field defining an electrical potential gradient, through which electrical field said primary liquid is directed from said nozzle so as to expose said primary liquid to said electrical potential gradient and so as to deflect said primary liquid by exposure to said electrical field.

8. A method according to any of the preceding claims, further comprising the step of interrupting the ejection of said curable liquid from said liquid discharge means by interrupting said ejection of said primary liquid through said thin layer of said secondary liquid.

9. A method according to claim 8, wherein said interruption of said ejection of said primary liquid through said thin layer of said secondary liquid is accomplished by electrostatically deflecting said primary liquid ejected from said nozzle so as to direct said ejected primary liquid away from said thin layer of said secondary liquid.

10. A method according to any of the preceding claims, further comprising the step of moving said discharge means and said supporting body relative to one another so as to form a deposition of a layer configuration on said surface.

11. A method according to any of the preceding claims, wherein said circuit material is an electrically insulating material, a semiconductor material or an electrically conductive material.

12. A method according to any of the preceding claims, wherein said electronic circuit part constitutes a circuit track of an electronic circuit.

13. A method according to any of the preceding claims, wherein said electronic circuit part constitutes an electronic component such as a passive electronic component, e.g. a resistor, an inductor or a capacitor, or an active component or part thereof.

14. A method according to any of the preceding claims, wherein said supporting body is a circuit board, such as a printed circuit board, a base board of a printed circuit board, such as a single-sided, a double-sided or multilayer printed circuit board, a thick-film or a thin-film substrate, or a component of electrically insulating or electrically conductive material, such as a component of a housing of an electronic apparatus or a terminal of an electronic component, such as an IC-chip or an IC-housing.

15. A method according to any of the preceding claims, wherein said curable liquid is a heat-curable liquid.

16. An apparatus for producing an electronic circuit part, which contains a circuit material distributed therein, on a surface of a supporting body, comprising:

a means for supporting said supporting body in said apparatus,

a means for ejecting, under pressure, a primary liquid from a nozzle,

a means for providing a thin layer of a secondary liquid, through which thin layer of said secondary liquid said primary liquid is ejected so as to form a compound liquid stream breaking up into a jet of compound liquid droplets, said compound liquid being a curable liquid containing said circuit material,

a liquid discharge means for discharging said jet of compound liquid droplets, and

a means for directing said jet of liquid droplets towards said surface of said supporting body so as to form a deposition of said curable liquid on said surface.

17. An apparatus according to claim 16, wherein said circuit material is constituted by particles contained in said secondary liquid, and wherein said primary liquid is particle-free.

18. An apparatus according to claim 16 or 17, wherein said secondary liquid is maintained under substantially atmospheric pressure conditions.

19. An apparatus according to claim 18, wherein said secondary liquid is maintained in a container having opposite apertures defining therebetween, through the forces of surface tension of said secondary liquid, said thin layer of said secondary liquid.

20. An apparatus according to any of the claims 16-19, wherein said primary and secondary liquids together constitute a two-component curable ink, such as an epoxy or polymer base.

21. An apparatus according to any of the claims 16-20, further comprising means for providing an electrical field defining an electrical potential gradient, through which electrical field said jet is directed so as to expose said liquid droplets of said jet to said electrical potential gradient and so as to deflect said jet by exposure to said electrical field.

22. An apparatus according to any of the claims 16-21, further comprising a means for providing an electrical field defining an electrical potential gradient, through which electrical field said primary liquid is directed from said nozzle so as to expose said primary liquid to said electrical potential gradient and so as to deflect said primary liquid by exposure to said electrical field.

23. An apparatus according to any of the claims 16-22, further comprising an electrostatical means for deflecting said primary liquid ejected from said nozzle so as to direct said ejected primary liquid away from said thin layer of said secondary liquid and so as to interrupt said ejection of said primary liquid through said thin layer of said secondary liquid.

24. An apparatus according to any of the claims 16-23, further comprising a means for curing said deposition of said curable liquid.

25. An apparatus according to any of the claims 16-24, further comprising means for moving said discharge means and said supporting body relative to one another so as to form a deposition of a layer configuration on said surface.

26. An apparatus according to any of the claims 16-25, wherein the curing means is a heating means for heating said curable liquid being a heat-curable liquid.

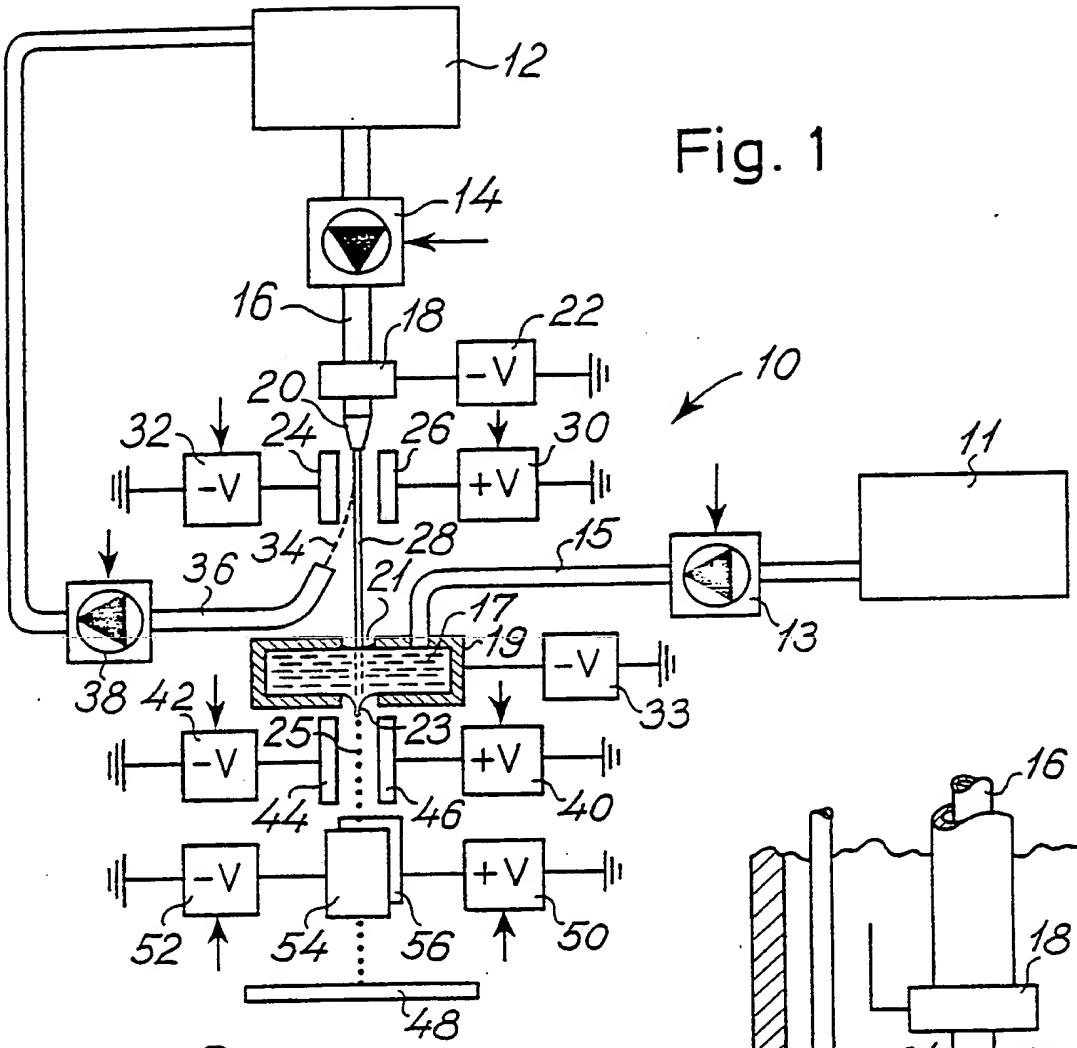


Fig. 1

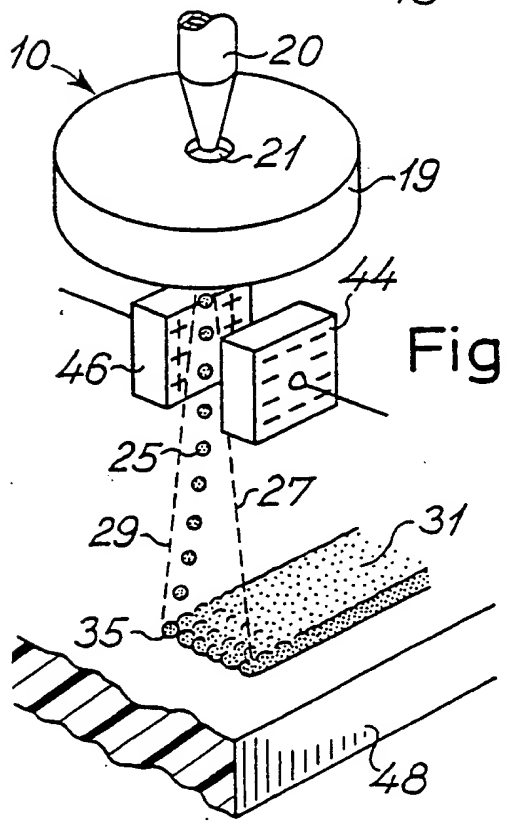


Fig. 3

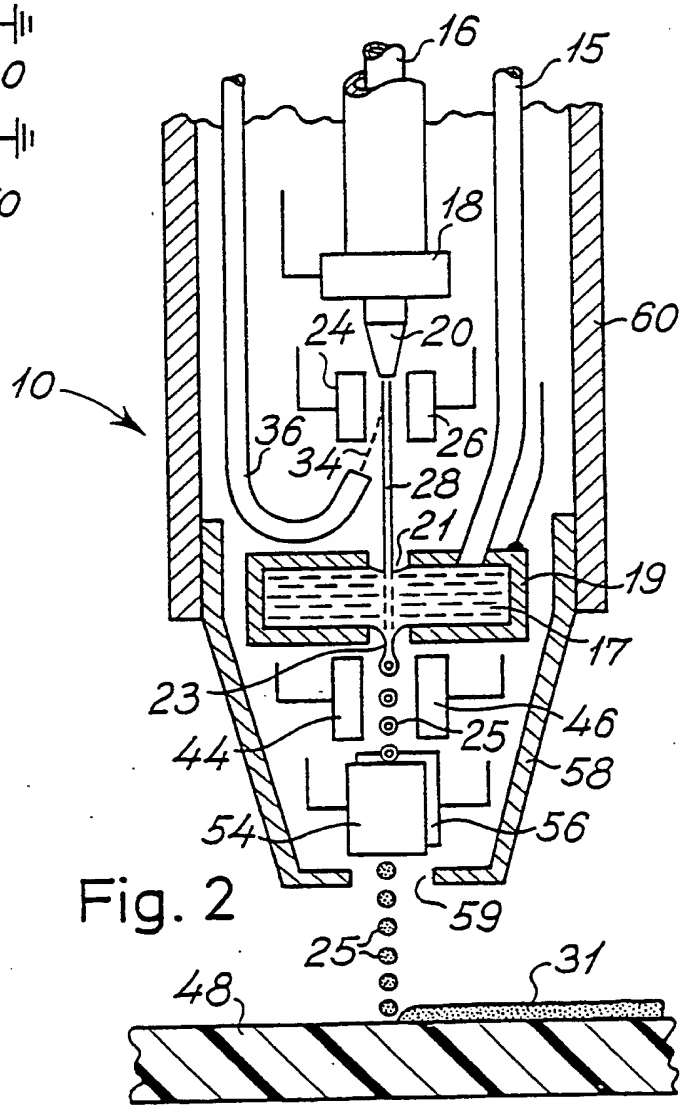


Fig. 2

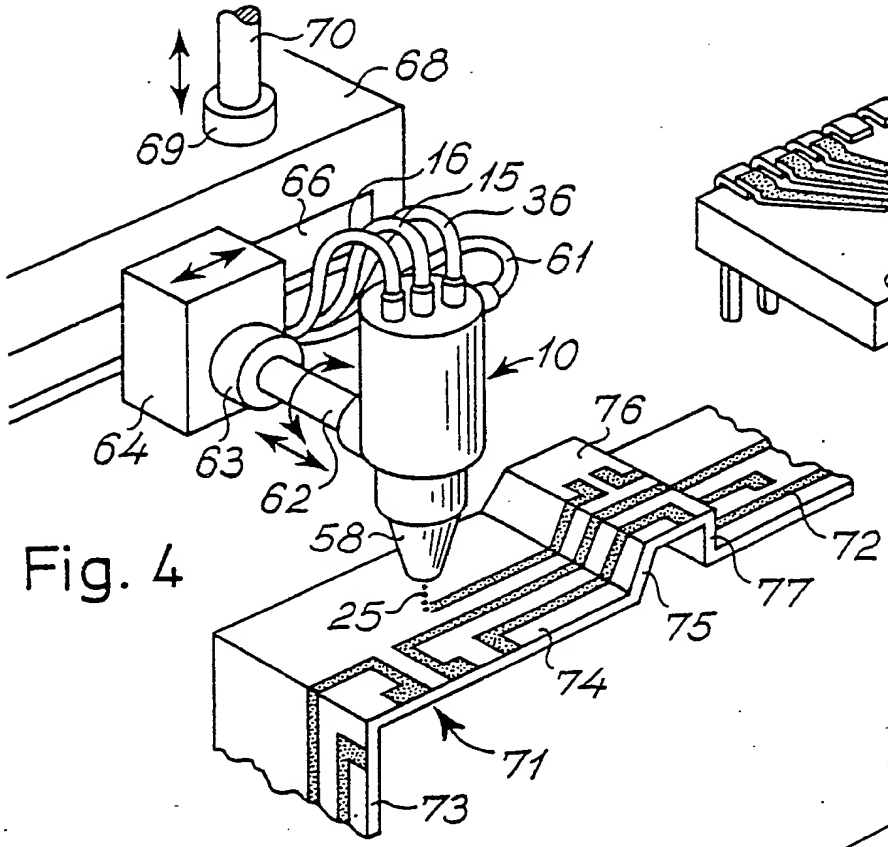


Fig. 4

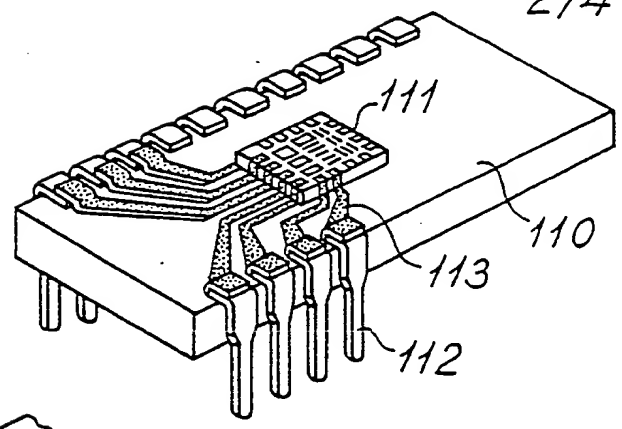


Fig. 7

Fig. 6

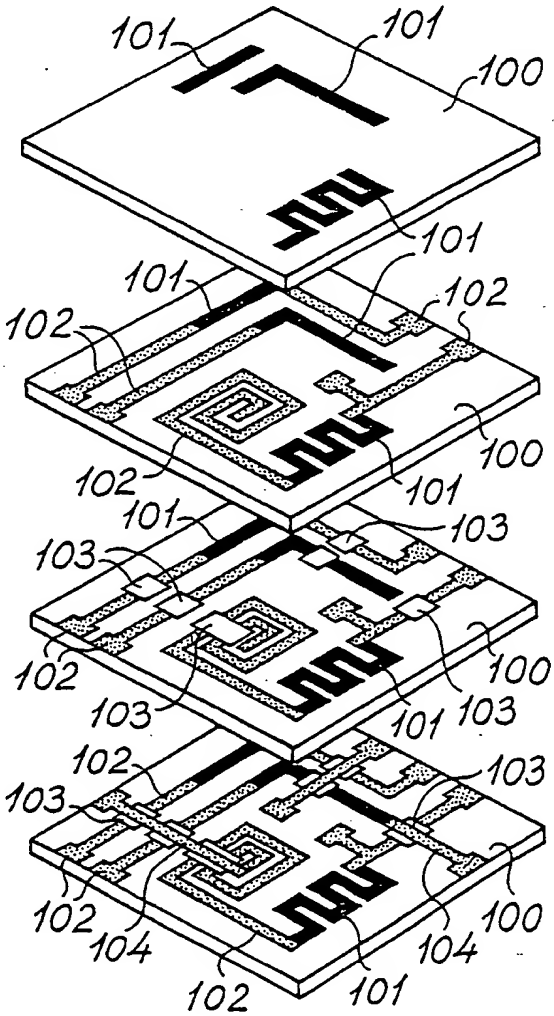
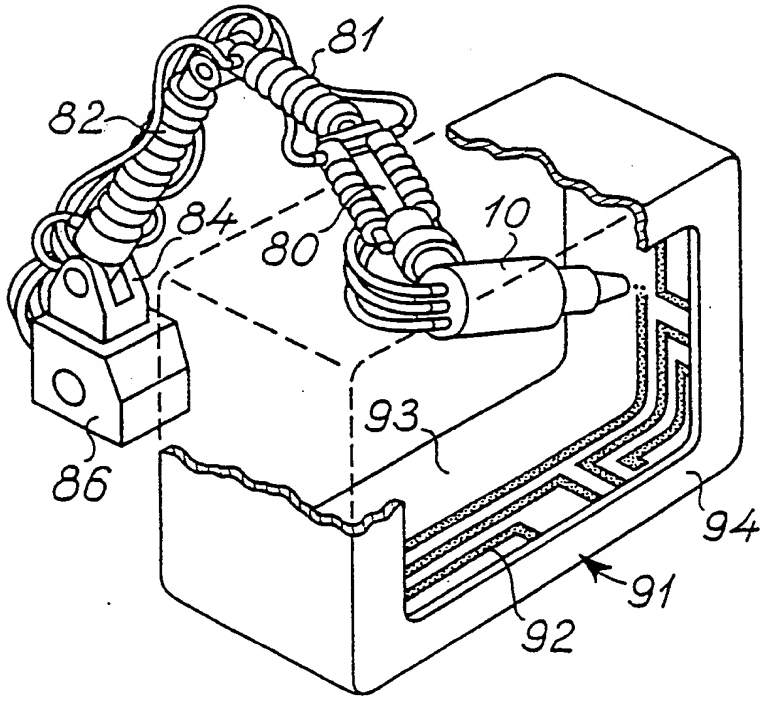


Fig. 5



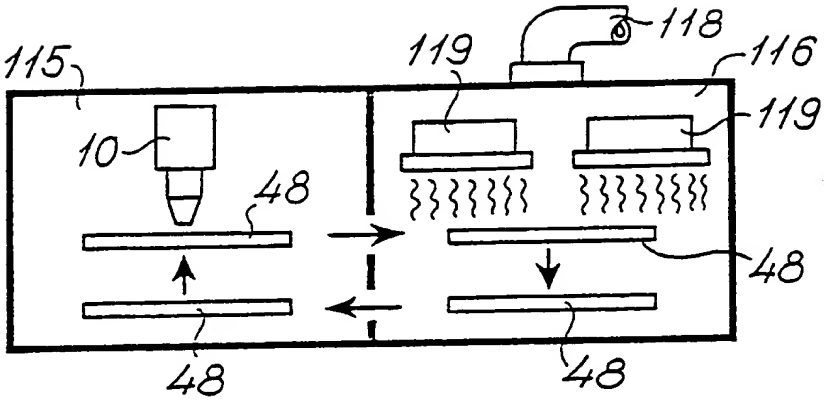


Fig 8

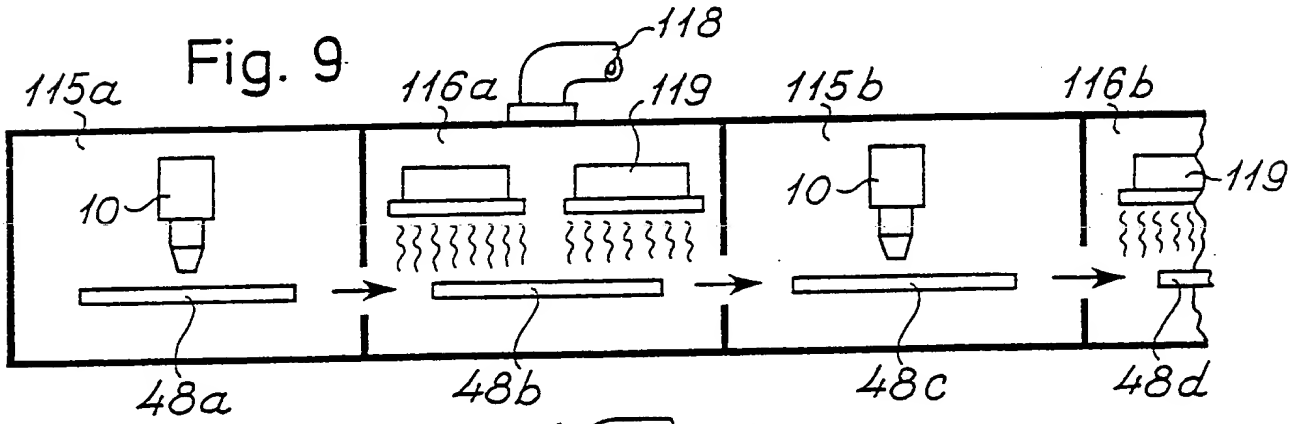


Fig. 9

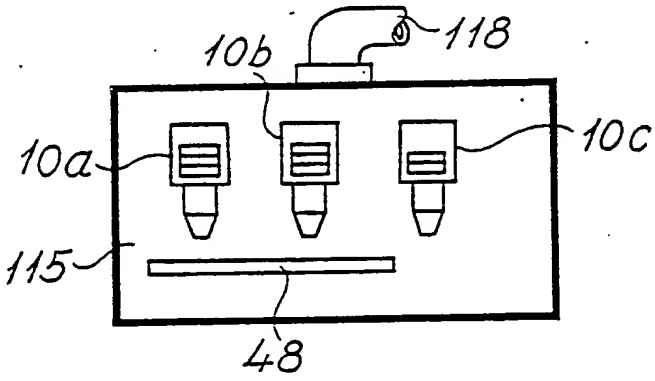


Fig. 10

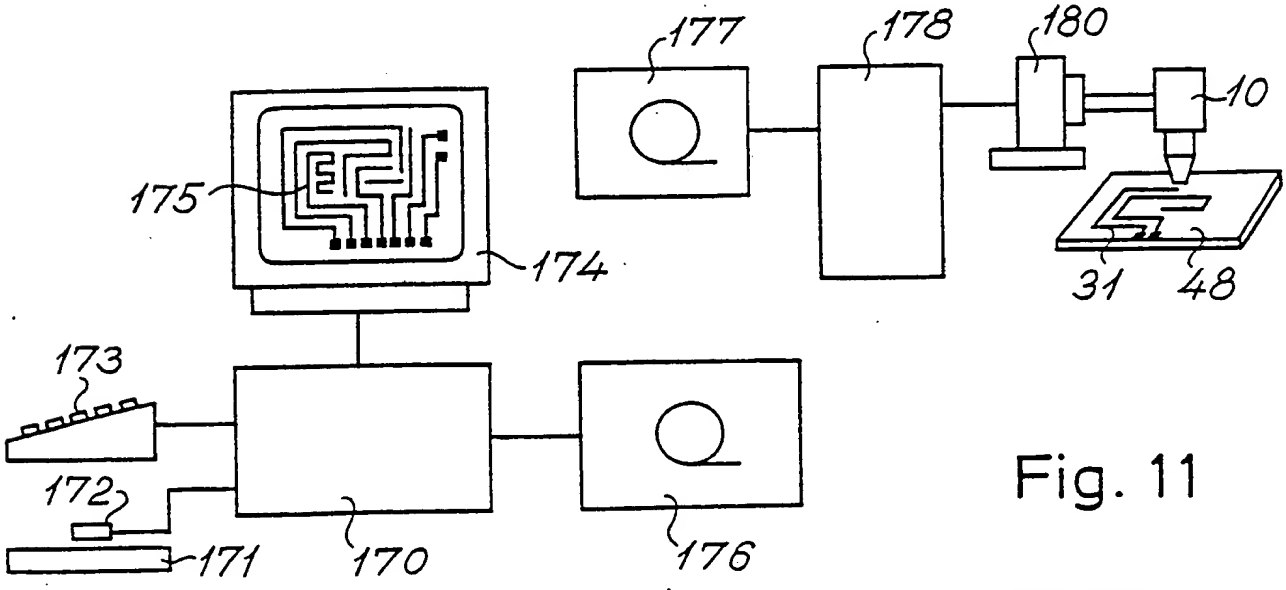
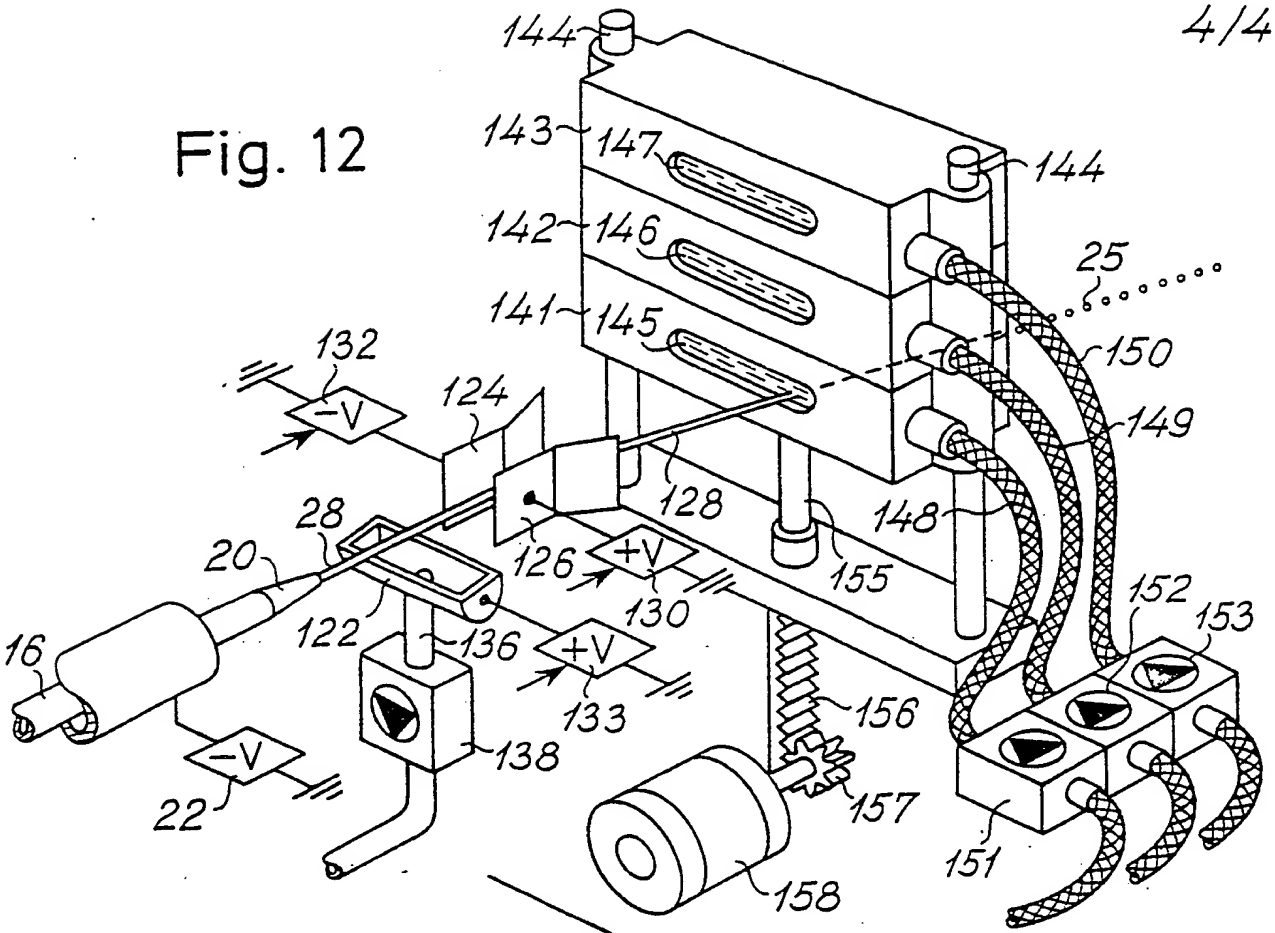


Fig. 11

Fig. 12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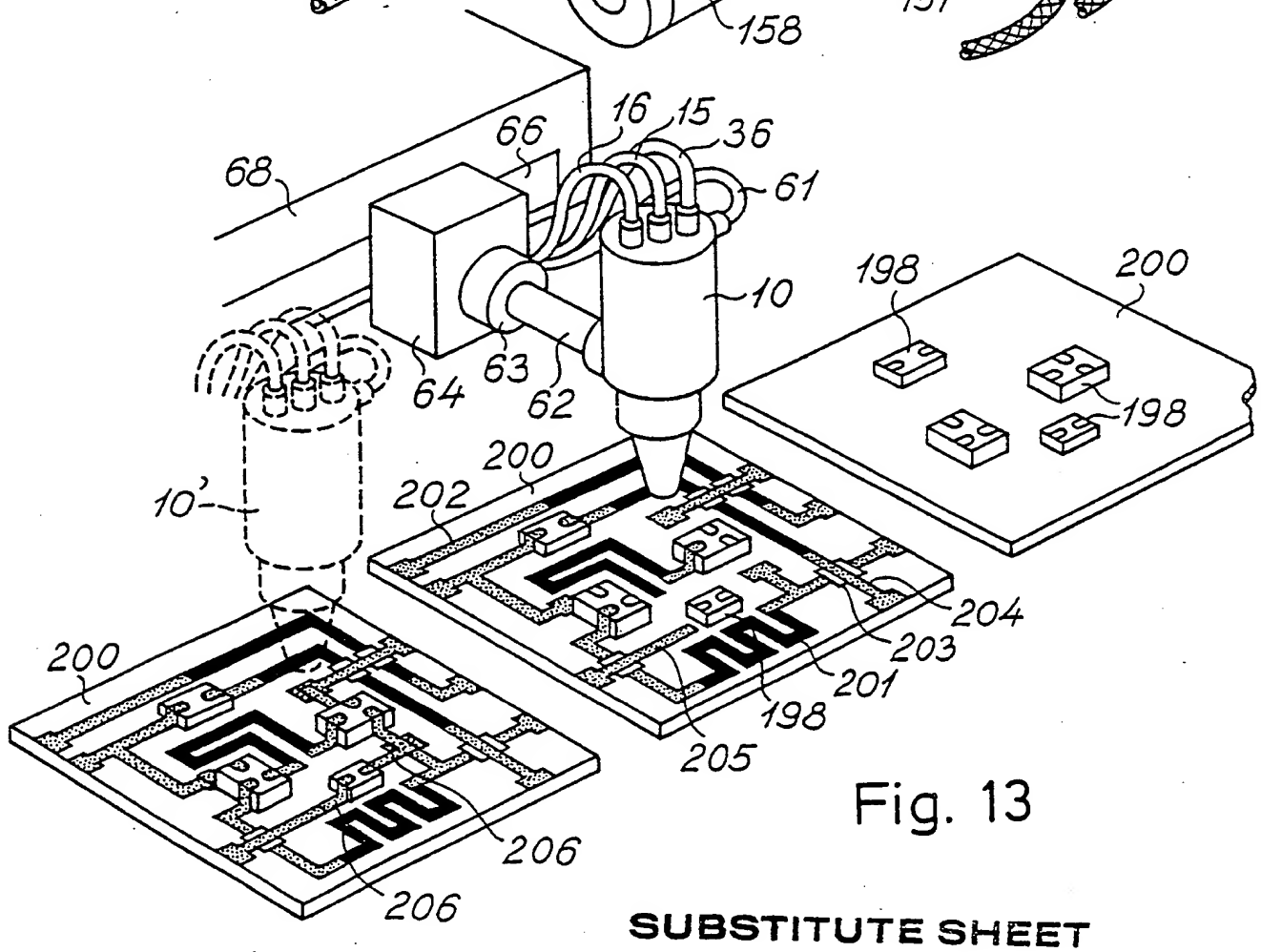
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Fig. 13

INTERNATIONAL SEARCH REPORT

International Application No PCT/DK 88/00206

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [6]

According to International Patent Classification (IPC) or to both National Classification and IPC [4]

H 05 K 3/14

II. FIELDS SEARCHED

Minimum Documentation Searched [7]

Classification System	Classification Symbols
IPC 4	H 05 K 3/10, /14, /16
US Cl.	361: 402; 427: 126, 287; 29: 829, 846, 852

Documentation Searched other than Minimum Documentation to the Extent that such Documents are included in the Fields Searched [8]

SE, NO, DK, FI classes as above

III. DOCUMENTS CONSIDERED TO BE RELEVANT [9]

Category *	Citation of Document, [11] with indication, where appropriate, of the relevant passages [12]	Relevant to Claim No. [13]
Y	US, A, 4 196 437 (HERTZ) 1 April 1980 & FR, 2340141 DE, 2704514 JP, 52096026 CH, 614158 GB, 1558585 CA, 1082285 SE, 400841	1-5, 16-20
Y	WO, A1, 86/01 747 (ROBERT BOSCH GMBH) 27 March 1986 & DE, 3434334 EP, 0194272	1, 6, 7, 10-15, 16, 21-26
Y	DE, A1, 3 539 781 (ESME-TECH ENGINEERING & ELEKTRONIK GMBH) 14 May 1987	1, 6, 7, 10-15, 16, 21-26
A	EP, A1, 0 132 677 (BAYER AG) 13 February 1985	1
A	DE, B2, 2 316 178 (LICENTIA PATENT-VERWALTUNGS GMBH) 6 February 1975	1

* Special categories of cited documents: [10]

"A" document defining the general state of the art which is not considered to be of particular relevance

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"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
1989-03-02	1989 -03- 06
International Searching Authority	**Signature of Authorized Officer**
Swedish Patent Office	Margareta Jonason

Form PCT/ISA/210 (second sheet) (January 1985)